Performance of Imported Strains of New Hampshires Under Hawaiian Conditions

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CONTENTS

Cover photo of New Hampshire pullet by E. J. Britten, Botany Department, University of Hawaii.

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INTRODUCTION

Poultrymen of Hawaii have been and are now dependent on mainland breeders for a supply of replacement stock both for egg and meat production. An unpublished 1950 summary from the Animal Industry Division of the Territorial Board of Agriculture and Forestry, Honolulu, notes that 1,061,820 chicks and 97,960 dozen hatching eggs were imported during 1949. The opinion that birds bred on the Mainland do not perform well in Hawaii is commonly expressed, and a frequent complaint is voiced against excessive mortality among imported strains. Yet, comparatively few chicks are hatched from locally produced eggs and there is practically no pedigree breeding and hatching.

At the poultry farm of the University of Hawaii a selection program for economic characters in New Hampshires has been inaugurated. This project was initiated to procure information on the rate of improvement that may be expected under Hawaiian conditions in a closed population of approximately 500 chickens, as well as to demonstrate the application of pedigree breeding through the utilization of progeny testing and family selection. Thus this project may serve as a model for poultrymen who may choose to inaugurate a pedigree breeding program and could serve as a basis of comparison insofar as changes may be recorded in population performance during subsequent generations. Hatching eggs and chicks were procured from three mainland breeders during the spring of 1949. Particular emphasis was placed on the restriction that the source farms be widely separated, thereby reducing the possibility that the progenitors of these strains had come from the same farm during recent years. This was done to ensure the procurement of strains that possibly had become genetically distinct for certain genes, at least, through selection toward different ideals as well as by chance recombinations. These strains were equivalent in breeding to U. S. Certified and were representative of the better quality chicks most frequently imported by territorial poultrymen. Chicks were also produced from equivalent matings of the local experiment station stock for comparative purposes, and the four strains were reared together under a similar environment. The data presented in this bulletin represent the group performance of each strain almost from date of hatch through more than 11 months of egg production.

This study has provided an opportunity to compare the mainland strains under an environment that differed greatly from those under which the parental populations had been reared and maintained. The imported chicks were reared and maintained on wire floors (typical for Hawaii) and were denied green grass, insects, soil, and fermenting litter. Consequently, any nutritional requirement beyond that provided by our rations could not be supplemented and would therefore be reflected in the over-all performance of each strain. In contrast was the station flock that had been perpetuated under these conditions for several generations.

The primary purpose of this report is to record the performance of the population that will be referred to as the parental generation (P_1) of our selection program. These data constitute the base for comparison of future generations, for measurement of progress or lack of progress, and also, possibly, as an indication of the degree of variation that may be encountered between strains of a single variety of chickens.

MATERIALS AND METHODS

Eggs from Hawaii (strain A) and California (strain B) were hatched on March 3, 1949, at the poultry farm of the University of Hawaii. Ninety chicks were hatched from strain A and 281 chicks from strain B. Since it was not possible to arrange for the shipment of eggs from Washington (strain C) and Oregon (strain D), day-old chicks were hatched within 72 hours of the other strains and were shipped via air. Two hundred and sixty-seven chicks were imported from Washington and 210 chicks from Oregon, bringing the total to 848 chicks that were started during the first week in March.

The chicks were fed the rations shown in table 1. The starter ration was fed to 6 weeks of age, the grower ration to 20 weeks, and the layer ration thereafter.

TABLE 1. Formulas of rations fed to the four strains

INGREDIENTS	RATIONS		
	Starter	Grower	Layer
	pounds	*pounds*	*pounds*
Ground corn	27.0	21.0	30.0
Cracked corn	0.0	20.0	0.0
Ground wheat	20.0	17.5	30.0
Whole wheat	0.0	10.0	0.0
Ground oats	10.0	0.0	19.0
Ground barley	0.0	9.0	0.0
Herring meal	5.0	4.2	5.5
Meat scrap	5.0	0.0	0.0
Soybean oil meal	26.0	12.5	9.0
Alfalfa meal	5.0	4.2	5.0
Ground oyster shell	1.0	0.5	0.0
Deflourophos	0.5	0.6	1.0
Salt	0.5	0.5	0.5
Manganese sulfate (gm.)	10.0	5.0	2.5
Delsterol (gm.)	10.0	10.0	30.0
Choline chloride (gm.)	125.0	0.0	0.0
Fortafeed (gm.)	0.0	30.0	10.0
Riboflavin (mg.)	160.0	0.0	35.0

The chicks were started in electric battery brooders and reared to 4 weeks of age. They were then removed, vaccinated for fowl pox, and placed in grower batteries for 2 weeks. At that time they were vaccinated with formalin-inactivated Newcastle disease vaccine, separated as to sex, and transferred to open-air, wire-floor developer pens. At 18 weeks of age the birds were again vaccinated for Newcastle disease, and as they approached sexual maturity were leg-banded and housed in 14-×18-inch individual cages.

Records were procured on feed consumption, rate of growth, rate of feathering, incidence of mortality and perosis, physical defects and disqualifications, age at sexual maturity, egg production, egg weight, and certain egg characteristics.

RESULTS AND DISCUSSION

RATE OF GROWTH

In table 2 is shown the biweekly growth attained by each strain to 12 weeks for males and 24 weeks for females. There was a highly significant difference between the strains for rate of growth. At 12 weeks of age strain A males averaged 1,546.8 grams; strain B, 1,650.7 grams; strain C, 1,492.4 grams; and strain D, 1,588.7 grams. Among the females, strain A averaged 1,250.3 grams; strain B, 1,493.9 grams; strain C, 1,311.1 grams; and strain D, 1,311.1 grams. Strain B was most desirable for meat production to 12 weeks of age. At 24 weeks of age there was 0.84 pound difference (383.4 grams) between the body weights of the heaviest and lightest strains. In sequence, strain A females averaged 2,172.2 grams; strain B, 2,555.6 grams; strain C, 2,315.8 grams; and strain D, 2,296.1 grams. The environment did not adversely affect growth rate in the imported strains; indeed, at 24 weeks of age the local strain was the smallest.

FEED CONSUMPTION

In table 3 is shown the biweekly feed consumption of the males of each strain to 12 weeks of age and of the females to 24 weeks of age. The males consumed on the average 5,273.8 grams of feed in strain A, 4,985.8 grams in strain B, 5,282.3 grams in strain C, and 5,357.6 grams in strain D; whereas the females ate, respectively, 4,172.8, 4,706.9, 4,325.9, and 4,447.5 grams to 12 weeks of age. By 24 weeks of age, strain A averaged 12,236.2; strain B, 14,283.3; strain C, 12,738.2; and strain D, 13,094.2 grams of feed.

ECONOMY OF FEED CONVERSION

The units of feed per unit of gain to 12 weeks for males were 3.41 (strain A), 3.02 (strain B), 3.54 (strain C), and 3.37 (strain D). Similarly, the units of feed per unit of gain for females were 3.34, 3.15, 3.30, and 3.39, respectively. Strain B not only showed the fastest rate of growth to 12 weeks of age (for both sexes) but also was the most economical in feed utilization. By 24 weeks of age the units of feed per unit gain for females were 5.63 (strain A), 5.59 (strain B), 5.50 (strain C), and 5.70 (strain D). These values indicate that efficiency in feed utilization of the imported strains was not impaired by the new environment; therefore, imported strains may be expected to grow efficiently in Hawaii. Furthermore, the greater rate of

TABLE 2. Biweekly body weights of the four strains of New Hampshires

WEEKS	STRAIN A			STRAIN B			STRAIN C			STRAIN D		
	Males and Females	Males	Females	Males and Females	Males	Females	Males and Females	Males	Females	Males and Females	Males	Females
	grams	*grams*	*grams*	*grams*	*grams*	*grams*	*grams*	*grams*	*grams*	*grams*	*grams*	*grams*
2	111.2	.....	.....	127.7	.....	.....	109.0	.....	.....	96.7	.....	.....
4	280.0	.....	.....	327.4	.....	.....	284.9	.....	.....	275.2	.....	.....
6	....	569.1	495.5	....	684.0	613.1	....	595.2	523.8	....	584.3	508.9
8	....	841.2	717.8	....	901.4	865.5	....	835.9	760.3	....	877.5	766.7
10	....	1,275.0	1,078.9	....	1,375.6	1,250.8	....	1,293.0	1,102.4	....	1,291.7	1,105.1
12	....	1,546.8	1,250.3	....	1,650.7	1,493.9	....	1,492.4	1,311.1	....	1,588.7	1,311.1
14	....	.....	1,391.5	....	.....	1,704.1	....	.....	1,432.9	....	.....	1,499.4
16	....	.....	1,577.6	....	.....	1,901.5	....	.....	1,659.7	....	.....	1,669.4
18	....	.....	1,761.3	....	.....	2,118.9	....	.....	1,858.3	....	.....	1,906.7
20	....	.....	1,908.5	....	.....	2,264.8	....	.....	2,004.3	....	.....	2,007.6
22	....	.....	2,083.8	....	.....	2,487.3	....	.....	2,202.9	....	.....	2,209.6
24	....	.....	2,172.2	....	.....	2,555.6	....	.....	2,315.8	....	.....	2,296.1

TABLE 3. Biweekly feed consumption of the four strains of New Hampshires*

WEEKS	STRAIN A			STRAIN B			STRAIN C			STRAIN D		
	Males and Females	Males	Females	Males and Females	Males	Females	Males and Females	Males	Females	Males and Females	Males	Females
	grams	*grams*	*grams*	*grams*	*grams*	*grams*	*grams*	*grams*	*grams*	*grams*	*grams*	*grams*
2	160.2	.....	.....	165.6	.....	.....	144.7	.....	.....	127.0	.....	.....
4	420.0	.....	.....	434.2	.....	.....	428.6	.....	.....	420.0	.....	.....
6	884.0	.....	.....	810.2	.....	.....	909.3	.....	.....	860.4	.....	.....
8	....	1,190.7	763.8	....	941.4	907.0	....	1,244.2	730.2	....	1,123.3	894.4
10	....	1,208.3	923.3	....	1,184.3	1,093.1	....	1,215.2	978.1	....	1,263.8	982.4
12	....	1,410.6	1,021.5	....	1,450.1	1,296.8	....	1,340.3	1,135.0	....	1,563.1	1,163.3
14	....	.....	1,060.7	....	.....	1,375.3	....	.....	1,198.9	....	.....	1,214.0
16	....	.....	1,096.4	....	.....	1,353.2	....	.....	1,204.1	....	.....	1,176.2
18	....	.....	1,149.2	....	.....	1,425.0	....	.....	1,195.8	....	.....	1,265.3
20	....	.....	1,410.2	....	.....	1,638.4	....	.....	1,323.0	....	.....	1,429.2
22	....	.....	1,600.3	....	.....	1,855.4	....	.....	1,695.7	....	.....	1,756.7
24	....	.....	1,746.6	....	.....	1,929.1	....	.....	1,794.8	....	.....	1,805.3
Total	....	5,273.8	12,236.2	....	4,985.8	14,283.3	....	5,282.3	12,738.2	....	5,357.6	13,094.2

*The biweekly feed data were recorded for combined sexes to 6 weeks of age; thereafter the data were recorded separately.

growth coupled with efficiency of feed conversion demonstrated that the imported strains in this study were genetically superior to the local strain for these characters.

Records on feed consumption for each strain from 18 weeks of age to the end of this study were also kept. It was observed that strain A, for example, consumed a total of 3,506.75 pounds of feed during this interval, and produced 7,084 eggs. From this it was calculated that 5.94 pounds of feed were consumed to produce a dozen eggs. The efficiencies were similarly calculated for the other strains: strain B required 7.25 pounds; strain C, 5.47 pounds; and strain D, 6.27 pounds of feed per dozen eggs. Since the hen-housed production of the four strains was 195.7 (strain A), 155.7 (strain B), 199.4 (strain C), and 167.5 (strain D) eggs, it is seen that efficiency of feed utilization was directly associated with rate of lay. Only one of the three imported strains produced eggs as efficiently as the local strain.

MORTALITY

During the brooding stage livability of the four strains was excellent. At 6 weeks of age the mortalities were 1.1 percent (strain A), 1.4 percent (strain B), 1.9 percent (strain C), and 0.0 percent (strain D). Since the chicks from strains C and D had been hatched on the Mainland and shipped via air, the very low mortalities were impressive. Under the conditions of this experiment it may be concluded that livability to 6 weeks of age was as good for the imported chicks as for chicks from imported or locally produced eggs. Hutt (*6*) reported a communication from Malta in which three imported breeds were compared with native stock (Maltese Blacks). All chicks were hatched in the same incubators, and after a month the mortalities were as follows: White Leghorns, 26 percent; Rhode Island Reds, 21 percent; Buff Plymouth Rocks, 32 percent; and Maltese Blacks, 7 percent.

In the present experiment, at 12 weeks of age the comparison was not as favorable for the imported strains. Whereas only 1.1 percent died from strain A, the mortalities for the other strains were: 4.6 percent (strain B), 6.4 percent (strain C), and 6.7 percent (strain D). The primary causes of death in these strains were picking and paralysis. Since the same number of birds was placed in each developer pen (40 per 90 square feet), the occurrence of cannibalism in the imported strains is suggestive of restricted adaptation to the new system of management. Whether this explanation is correct, however, cannot be concluded from this single comparison.

The hen-house mortality was fairly well associated with mortality to 12 weeks of age. Following approximately 1 year of confinement in individual cages, the hen-house mortality, due to all causes, was 5.6 percent for strain A, 19.8 percent for strain B, 17.1 percent for strain C, and 27.1 percent for strain D. The primary cause of mortality was the avian leucosis complex. These are highly significant and noteworthy differences.

During the growing stage to 12 weeks of age, the mortality of the imported strains was 4 to 6 times greater than that of the local strain, and 3 to 5 times greater during the adult phase. These data suggest that in this experiment, at least, resistance to disease was not as well developed in the imported strains as in the controls. These observations are in agreement with local opinion that imported strains oftentimes perform poorly, mortality being a problem of grave concern.

There is a problem then in regard to livability. Because the extent to which the incidence of disease organisms differs between the West Coast and Hawaii is not known, it is fruitless to speculate that chicks imported from the Mainland become more heavily infected locally, although such may be the case. Nor do we know at present to what extent rearing birds on wire as compared with litter and range contributes to higher mortality in Hawaii. The fact remains that in this study mortality was consistently greater in the imported strains. This observation suggests the need for selective breeding among mainland breeders for higher resistance to local strains of disease organisms and management if their stocks are to survive well in Hawaii. Of greater practical importance would be the development of local poultry breeding farms where birds can become adapted through selection under similar local conditions.

PEROSIS

A striking example of adaptation was shown upon analysis of the incidence of perosis among the four strains of New Hampshires. At 12 weeks of age the total percentage of birds showing definite symptoms of perosis was 0.0 in strain A, 3.9 in strain B, 5.2 in strain C, and 4.8 in strain D. The local strain was maintained on wire for several generations; the mainland strains had not been similarly managed. Presumably selection was enforced against perosis in all strains, since perotic individuals would not be used as breeders. However, the selective pressure against perosis may have been greater for the wire-reared birds, since they could not supplement their diet. Under this system of management only birds that could grow well on the nutrients supplied solely in their ration were selected as breeders, and selective pressure was applied against the gene frequencies (unknown) for higher requirements or defective assimilation of either manganese, biotin, pantothenic acid, nicotinic acid, choline, and possibly methionine, singly or in combination. Serfontein and Payne (*13*) have shown that susceptibility to perosis may be genetically influenced. They observed in "straight leg" Rhode Island Red matings that 18.6 percent of the offspring were perotic while in "crooked leg" matings in the same breed 50.0 percent were affected.

These results suggest that the imported strains, all of which grew faster than the local strain to 12 weeks of age, had a higher requirement for those factors needed for normal growth and developed perosis ranging in frequency from 3.9 to 5.2 percent. It would appear that for rapidly growing strains reared on wire special supplementation of the diet is necessary to prevent perosis. Furthermore, there is evidence that a ration complete for one breed may not be adequate for another. Gallup and Norris (*3*) have reported that their strain of New Hampshires had an incidence of 4 percent perosis when fed a diet containing up to 100 ppm of manganese, whereas White Leghorn chicks did not show any perosis when fed a diet as low as 30 ppm of manganese. And, Ewing (*2*) has reported that perosis is more likely to occur in birds that are raised in strict confinement. Another alternative, as suggested in the preceding section, would be the development of breeding programs in Hawaii in which birds reared on wire would produce progeny that would be reared on wire.

RATE OF FEATHERING

All chicks were feather scored at 14 days of age to identify rapid, normal phenotypes. The system of classification shown in table 4 was based on descriptions given by Warren (*15*) and Jones and Hutt (*9*). Since an excellent summary on the inheritance of rate of feathering and descriptions of the associated phenotypes has been contributed by Hutt (*6*), detailed descriptions of each classification are not included in this report. The classification "slow and retarded or tardy," not described in the above references, included chicks that at 14 days of age had practically no primary or secondary flight feather development and no shoulder feathers or tails.

Based on this sytem of classification a definite differentiation in rate of feathering was possible among the four strains. The percentage in each strain showing the recessive sex-linked gene for rapid feathering (k) was as follows: strain A, 81.1; strain B, 100.0; strain C, 70.7; and strain D, 78.6. The percentage showing the dominant autosomal gene for normal feathering (T) was as follows: strain A, 90.0; strain B, 100.0; strain C, 97.7; and strain D, 83.8. Finally, the percentage of each strain showing rapid, normal feathering genotypes [(kx kx T–) or (kx Y T–)] was as follows: strain A, 71.1; strain B, 100.0; strain C, 68.8; and strain D, 63.8.

TABLE 4. Feather scores of the four strains of New Hampshires at 14 days of age

FEATHER SCORE	STRAINS			
	A	B	C	D
Rapid,* normal†	48	280	178	123
Rapid, normal with slight indentation of secondaries	16	1	5	11
Rapid, retarded	0	0	0	1
Rapid, tardy	9	0	5	30
Slow, normal	15	0	77	42
Slow, normal with slight indentation of secondaries	2	0	0	0
Slow, retarded or tardy	0	0	1	3
Total	90	281	266	210

*Rapid vs. slow—sex-linked alleles reported by Warren (*15*).
†Normal, retarded, and tardy—multiple alleles described by Jones and Hutt (*9*).

Rate of feathering is primarily controlled by genes (i.e., high heritability) although Gericke and Platt (*4*) reported poor feathering on diets low in protein, and Briggs *et al.* (*1*) have reported poor feathering on folic acid-deficient diets. The data in table 4 indicate that emphasis on rate of feathering was not equally applied or successful in these strains. Obviously the breeder who developed strain B had eliminated the genes for slow, retarded, and tardy feathering in the population under consideration.

DEFECTS AND DISQUALIFICATIONS

The incidence of defects and disqualifications observed in this study are shown in table 5. Side sprigs were observed in strain B only, at the high frequency of 9.9 percent. All strains, under our system of classification, showed slipped wings, the incidence ranging from 5.7 to 19.5 percent. Stubs and down were observed only in the imported strains. Crooked toes were frequent only in strain B, as was the classification "pupils not round." Only two pullets had telescopic blades.

TABLE 5. Summary of defects and disqualifications of females at 20 weeks of age

STRAIN	PERCENTAGE OF DEFECTS AND DISQUALIFICATIONS					
	Side sprigs	Slipped wings	Stubs and down	Crooked toes	Pupils not round	Telescopic blade
A	0.0	7.5	0.0	2.5	0.0	0.0
B	9.9	5.9	6.9	7.9	5.9	0.9
C	0.0	19.5	0.8	0.8	0.8	0.8
D	0.0	5.7	1.1	0.0	1.1	0.0

At present there is no improvement program (i.e., breeding stages) operating in Hawaii. Some day a selection program comparable to the National Poultry Improvement Program may be applied here. In that event a large proportion of the population summarized in table 5 would be declared disqualified from further participation. It would be wise, therefore, to keep this in mind and to stress freedom from inherent disqualifications and defects when purchasing foundation stock. It is evident from this study that the distribution of genes for such characters as side sprigs, slipped wings, stubs and down, and crooked toes was not uniform in the four strains.

SEXUAL MATURITY AND BODY WEIGHT

The maximum range in age at sexual maturity was 15.9 days. On the basis of all birds that matured (the last pullet matured at 215 days of age) mean age at sexual maturity for the four strains was as follows: strain A, 158.9 days; strain B, 151.7 days; strain C, 167.6 days; and strain D, 164.7 days. The average body weights of the four strains at 168 days of age were 2,172.2 grams for strain A, 2,555.6 grams for strain B, 2,315.8 grams for strain C, and 2,296.1 grams for strain D. These data suggest that age at first egg is inherited independently of body size, although Jull (*10*) generalized that within a strain the early maturing pullets tend to be smaller than the later maturing pullets. Strain B pullets had an average maturity of 151.7 days and weighed 2,555.6 grams at 168 days of age, while strain A had an average maturity of 158.9 days and an average weight of 2,172.2 grams at 168 days of age. The difference in this instance is 7.2 days in sexual maturity and 383.4 grams in body weight. Similarly, strain B matured earlier and weighed more than the other two strains. Evidence to support this idea may also be found in reports of others. Hays and Sanborn (*5*) reported an increase of 0.61 pound in body weight at sexual maturity from 1921 to 1932 while the mean age at first egg was reduced from 211.5 to 201.7 days. Waters (*16*), in crosses involving the White Leghorn × Light Brahma, reported that in the F_1 and F_2 generations certain birds with adult weights above 2,700 grams matured nearly as early as Leghorns that averaged only 1,600 grams in adult weight.

EGG WEIGHT

Egg weights were recorded for the first 10 eggs laid by each pullet, as well as for those produced during the first 3 days of each month. The average egg weight for the first 10 eggs produced by the pullets of each strain, exclusive of double-yolked eggs, was 46.20 (strain A), 45.36 (strain B), 45.98 (strain C), and 47.17 (strain D) grams. Maw and Maw (*11*) concluded from their data that the average weight of the first 10 eggs should be 47.5 grams if the pullets' eggs are to weigh about 56 grams before the end of the year.[1] On this basis eggs of none of these strains would have been expected to average 56 grams. Upon analysis of the eggs produced by each strain during the first 3 days of each month, the average egg weights were as follows: strain A, 56.44 grams; strain B, 59.15 grams; strain C, 55.91 grams, and strain D, 58.12 grams. Three of the strains exceeded 56 grams and one approached within 0.09 gram. These data suggest that other phenomena (environmental) were operative under our experimental conditions.

In figure 1 is shown the percentages of large eggs (56.7 grams) that were produced by each strain during the first 3 days of each month.

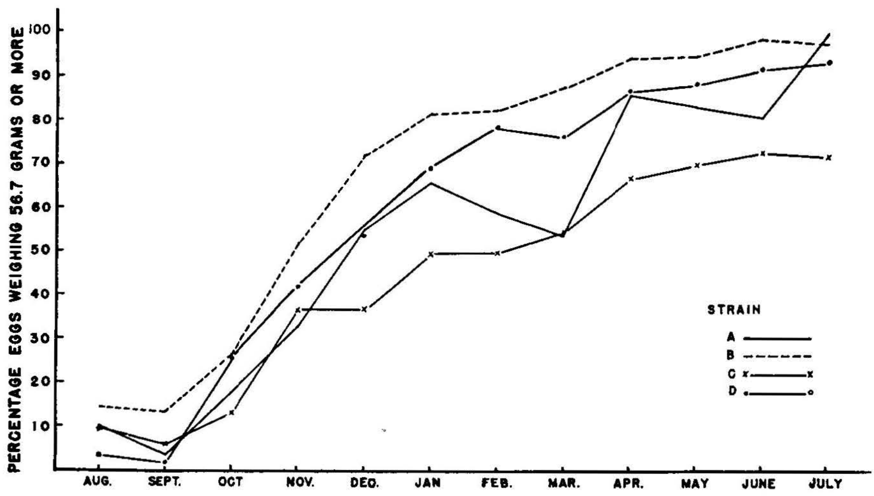

Fig. 1. Frequency of large eggs produced by each strain during first 3 days of each month.

EGG PRODUCTION

It is well known that egg production is a complex, being influenced by age at sexual maturity, intensity and persistency of production, pause, and broodiness. Data were recorded on all these characteristics except persistency, which was omitted because the study was terminated on July 31 and many birds were still in full production. Upon analysis of each strain, clutch size ranged from 2.14 to 2.59 eggs, the average number of pauses ranged from 1.44 to 2.33 per bird, and the frequency of broody birds ranged from 0.0 to 4.0 percent. These data are shown by strains in table 6. As mentioned above under the heading "Economy of Feed Conversion," the hen-house production to July 31, 1950, for strain A was 195.7 eggs; for strain B, 155.7 eggs; for strain C, 199.4 eggs; and for strain D, 167.5 eggs. Even though strain C possessed the most favorable gene frequency for intensity of pro-

[1]An egg weighing 56.7 grams = 2-ounce egg.

duction and freedom from pause, the production of strain A compared favorably with it; furthermore, strain A outproduced strain D by 28.2 eggs despite a somewhat smaller clutch size and similar frequency of pauses. This was possible because of the very low hen-house mortality of strain A. Whereas strains B, C, and D lost 19.8, 17.1, and 27.1 percent, respectively, strain A lost only 5.6 percent of pullets housed. It would appear, then, that no one strain was superior for all the characters affecting total egg production. Most outstanding was the difference in hen-house mortality among the four strains.

From figure 2 it may be concluded that the four strains laid quite uniformly, with strain B laying at the lowest rate and showing poorest persistency. Egg production of the imported strains did not appear to be adversely affected by the local environment.

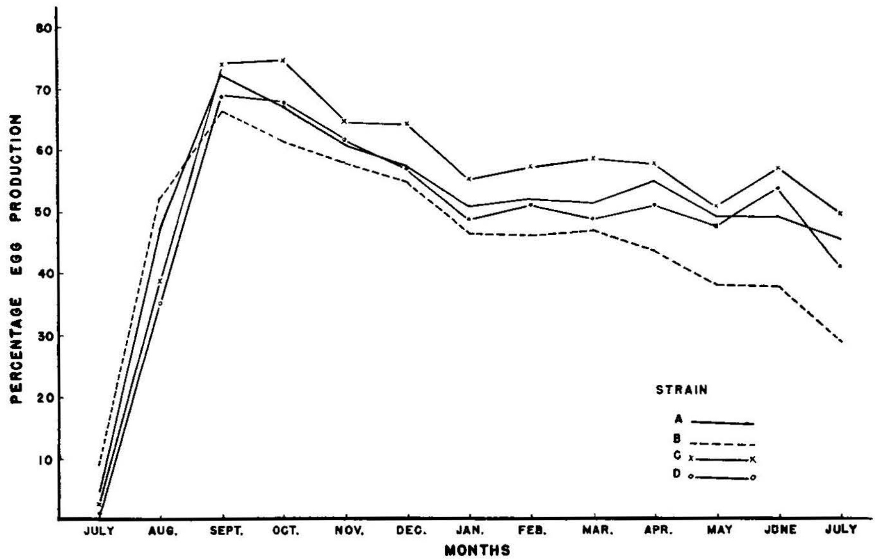

Fig. 2. Monthly hen-day egg production of the four strains of New Hampshires.

TABLE 6. Egg production and components for each strain

CHARACTERISTICS	STRAINS			
	A	B	C	D
Hen-house production	195.7	155.7	199.4	167.5
Age at sexual maturity (days)	158.9	151.7	167.6	164.7
Average clutch size*	2.15	2.14	2.59	2.24
Average number of pauses per bird†	1.86	2.33	1.44	1.84
Percentage broody one or more times	0.0	0.0	4.0	0.0
Percentage hen-house mortality	5.6	19.8	17.1	27.1

*Clutch size—number of eggs laid on consecutive days.
†Pause—non-production for 7 or more days.

DOUBLE-YOLKED EGGS

The percentage of double-yolked eggs was highest during the first 3 months of production: namely, July through September. Three of the strains produced their highest percentage during the first month of production, while strain B, although the earliest maturing, did not reach its peak until the second month. Thereafter the frequency of double-yolked eggs dropped steadily, as may be seen in figure 3. Only strain B produced double-yolked eggs every month.

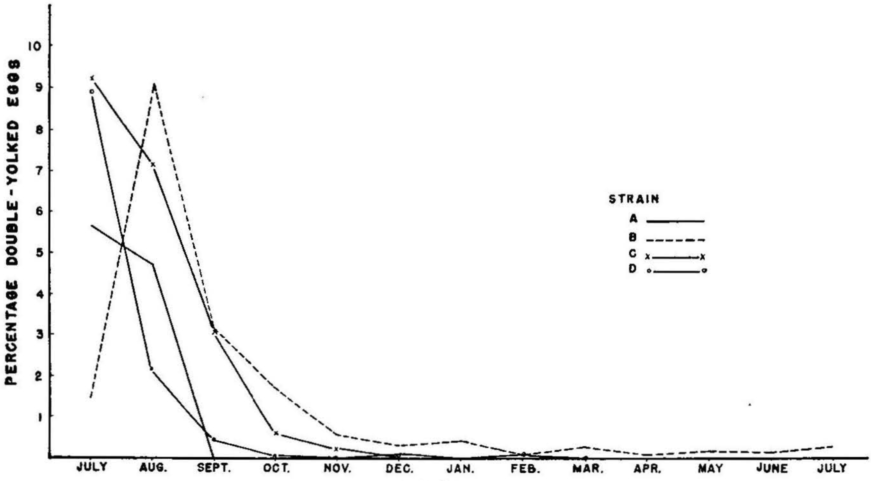

Fig. 3. Frequency of double-yolked eggs detected by candling.

MEAT AND BLOOD SPOTS

All eggs produced in this study (56,542 eggs) were candled, and careful records were kept on eggs detected as containing meat and blood spots. It was observed that all strains produced meat and blood spot eggs during every month; but the distribution was not uniform, the highest frequency occurring during the first 2 months. Thereafter, the frequency dropped to its lowest incidence in October, only to increase and level off by December. Strain C consistently showed the lowest frequency of detected eggs. It is recognized that the number detected by candling represented only a portion of the total. In a companion study on egg quality it was observed that only 21.5 percent of total meat and blood spot eggs were detected by candling (unpublished data). However, the data shown in figure 4 are still worthwhile since the commercial producer uses the same method of candling when packing eggs for market.

There are references in the literature to support the theory that this character is heritable. Nalbandov and Card (*12*) reported 12.8 percent meat spots in eggs from S. C. White Leghorns and 6.1 percent meat-spotted eggs from heavy breeds. Jeffrey (*8*), however, observed that Legbar eggs showed less than half as many blood spots as Rhode Island Red eggs, and Van Wagenen *et al.* (*14*) have reported that white eggs from S. C. White Leghorns contained only one-fourth as many meat spots as did brown eggs from American breeds. Jeffrey and Pino (*7*) have also reported strain differences between S. C. White Leghorns. The analysis shown in table 7 indicates that the variation among the four strains was highly significant for frequency of meat and blood-spotted eggs and lends additional support to the theory that differences in this character may exist between strains as well as among breeds.

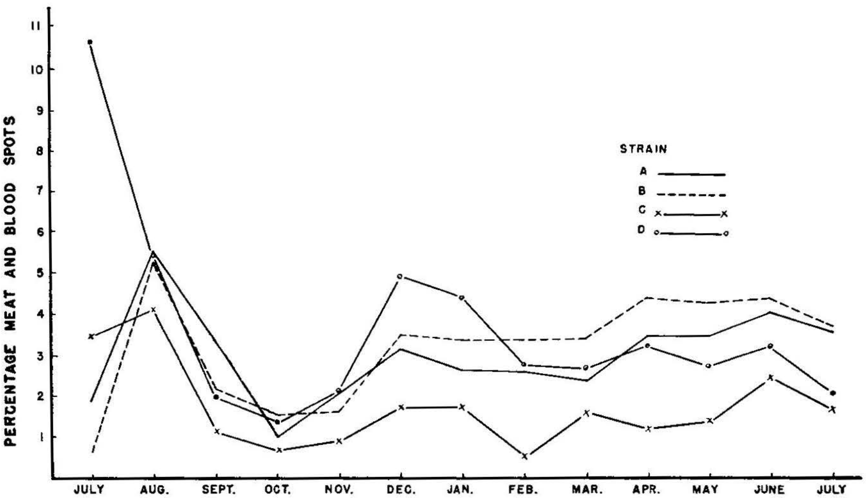

Fig. 4. Frequency of meat and blood spots detected by candling.

STATISTICAL ANALYSES OF CHARACTERS

In table 7 are listed the results of the statistical analyses of the characters discussed above. The differences between strains were highly significant for growth of males and females to 12 weeks of age, body weight of females at 24 weeks, 10 and 17 months of age, hen-house mortality, hen-house and monthly hen-day egg production, and monthly production of eggs containing meat and blood spots. Characters that were significantly different between strains were mortality to 12 weeks, perosis to 12 weeks, and rate of feathering for gene k. The remaining measurements were not significantly different.

TABLE 7. Summary of statistical analyses of the comparisons between strains

COMPARISON	STATISTICAL ANALYSIS		SIGNIFICANT*	HIGHLY SIGNIFICANT**
	x^2	F		
Growth of males to 12 weeks	....	11.62	yes	yes
Growth of females to 12 weeks	....	14.22	yes	yes
Body weight of females at 24 weeks	33.00	....	yes	yes
Body weight of females at 10 months	88.16	....	yes	yes
Body weight of females at 17 months	121.26	....	yes	yes
Units of feed per unit gain—males	0.04	....	no	....
Units of feed per unit gain—females	0.01	....	no	....
Pounds of feed per dozen eggs	0.27	....	no	....
Mortality to 6 weeks	1.76	....	no	....
Mortality to 12 weeks	4.22	....	yes	no
Hen-house mortality	13.74	....	yes	yes
Incidence of perosis to 12 weeks	4.90	....	yes	no
Rapid feathering	5.60	....	yes	no
Normal feathering	1.77	....	no	....
Age at sexual maturity	0.92	....	no	....
Weight of first 10 eggs	0.04	....	no	....
Hen-house egg production	7.62	....	yes	yes
Monthly hen-day production	....	9.45	yes	yes
Monthly production of double yolks	....	0.92	no	....
Monthly production of meat and blood spots	....	4.48	yes	yes

*Significant—the probability that differences of this magnitude would not occur due to chance more often than 1 time in 20.

**Highly significant—as above, but not likely to occur more often than 1 time in 100.

CONCLUSIONS

Students of poultry, trained in the American Standard of Perfection, are prone to think of individuals belonging to the same variety as being more similar than individuals in a group representing several varieties. Indeed, for a few genes, at least, this may be the case. Hutt (*6*) has discussed the problem of distinguishing between varieties and how a single gene difference may determine whether a bird is catalogued as a member of one or another variety. When the four strains were compared in this study they complied phenotypically with the standard as being New Hampshires and probably were homozygous for those characters used in distinguishing this variety. But a consideration of the characters analyzed in table 7 tends to raise the question of the value of the name variety. Presumably alike, being New Hampshires, they nevertheless varied significantly for such important economic traits as growth rate, body size, livability, incidence of perosis, rate of feathering, egg production, and production of eggs containing meat and blood spots.

In Hawaii, at least, the purchase of chicks under the general heading of a varietal name is no guarantee of quality. Since the strains differed in this study, it is reasonable to assume that another study using unrelated strains of chickens would again reveal real differences, perhaps for the same characters. Poultrymen, therefore, should become acquainted with specific strains of chickens and buy them more on the basis of performance and less on advertisement.

Each of the characters in which the four strains differed significantly is genetically influenced. The development of strains resistant to death and perosis appears to be particularly important and perhaps can best be attained through the use of modern breeding principles and practices under local Hawaiian conditions. This would tend to comply with recommendations in a recent economic survey in which it was shown that the economic stability of the Territory of Hawaii would be strengthened through increased exports and decreased imports. Toward that end it is logical to suggest that greater interest be fostered in local poultry breeding and flock replacement.

SUMMARY

Four strains of New Hampshires, hatched within 3 days of each other, were reared and maintained under the same conditions to 17 months of age. Three of these strains were imported from the Mainland. Data were collected on rate of growth, economy of feed consumption, livability, perosis, defects and disqualifications, rate of feathering, age at sexual maturity, egg production, and certain internal egg characteristics. It was found that the four strains differed significantly in growth rate, adult body weight, livability to 12 weeks and hen-house mortality, incidence of perosis, rapid feathering, hen-house production, monthly hen-day production, and meat and blood spots. The local strain, maintained under Hawaiian conditions for several generations, was outstanding for livability during both the growing and adult stages as well as for freedom from perosis. The local strain produced about as well as the best imported strain and was definitely superior to the other two. Only in body size did the local strain compare unfavorably with the imported strains.

To increase resistance to death and perosis, it is suggested that chickens be subjected to a systematic program of selection under Hawaiian conditions.

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